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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, July to September 1990, with 1991 CEEE Events Calendar

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Center for Electronics and Electrical Engineering
Semiconductor Electronics Division
Gaithersburg, MD 20899

April 1991

26

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
John W. Lyons, Director

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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the twenty-sixth issue of a quarterly publication providing information on the technical work of the National Institute of Standards and Technology (formerly the National Bureau of Standards) Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcement covers the third quarter of calendar year 1990.

Organization of Bulletin: This issue contains citations and abstracts for Center publications published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author within each topic. Following each abstract is the name and telephone number of the individual to contact for more information on the topic (usually the first author). This issue also includes a calendar of Center conferences and workshops planned for calendar year 1991 and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U.S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Electronics Division in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electricity Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Institute of Standards and Technology and a number of other organizations, in both the Federal and private sectors; these are identified on page 26.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division. The current set is identified in the Additional Information section, page 19.

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SEMICONDUCTOR TECHNOLOGY PROGRAM

Dimensional Metrology

Postek, M.T., Keery, W.J., and Frederick, N.V., **Low-Profile Microchannel-Plate Electron Detector System for SEM**, Proceedings of the XIIth International Congress for Electron Microscopy, Seattle, Washington, August 12-18, 1990, pp. 378-379 (1990).

One main impetus of present-day scanning electron microscopy is in the low accelerating voltage mode. This mode of operation is useful for nondestructive inspection, especially in the on-line inspection and metrology of semiconductor samples. Today, the majority of the scanning electron microscopes used in nondestructive inspection utilize the standard Everhart/Thornley (E/T) detector or a modification of this detector as the main detection system. The E/T detector, although extremely efficient, suffers from poor signal-to-noise ratio at low accelerating voltages. This type of detector also suffers from alignment difficulties especially where linewidth measurement for semiconductor applications is concerned because of the uneven distribution of the collection field, which is possible especially if the detector is not located in a plane of symmetry of the specimen and electron beam. These limitations and others have recently led investigators to reconsider the design of secondary electron detection systems, especially for low accelerating voltage and metrological applications.
[Contact: Beverly Wright, (301) 975-2166]

Power Devices

Berning, D.W., **Semiconductor Measurement Technology: A Programmable Reverse-Bias Safe Operating Area Transistor Tester**, NIST Special Publication 400-87 (August 1990).

This document describes the circuits and construction of a transistor turn-off breakdown tester. Principles of operation for various circuits in the tester are discussed, as well as those for the complete system. Construction notes are given with layout guidelines. Complete circuit schematics are included, and details of constructions of special parts used in the tester are furnished. Specifications and performance data are also included in this document.
[Contact: David W. Berning, (301) 975-2069]

Oettinger, F.F., and Blackburn, D.L., **Semiconductor Measurement Technology: Thermal Resistance Measurements**, NIST Special Publication 400-86 (July 1990).

This Special Publication reviews the thermal properties of power transistors and integrated circuits and discusses methods for characterizing these properties. The discrete devices discussed include bipolar transistors and metal-oxide-semiconductor field-effect-transistors. Measurement problems common to these devices, such as deciding the reason a particular measurement is required, adequate reference temperature control, selection of a temperature-sensitive electrical parameter, and separation of electrical and thermal effects during measurement, are addressed. Due to the inherent difficulties in measuring and analyzing the thermal properties of active integrated circuits, an approach using specifically designed thermal test chips for evaluation of new die attachment and packaging schemes is finding wide acceptance in the industry. In this Special Publication, indirect (i.e., electrical) measurements, direct (e.g., infrared) measurements, and computer simulation techniques for thermally characterizing integrated circuits are discussed in terms of their usefulness in characterizing VLSI packages.
[Contact: Frank F. Oettinger, (301) 975-2054]

Photodetectors

Geist, J., Gardner, J.L., and Wilkinson,

Photodetectors (cont'd.)

F.J., **Surface-Field-Induced Feature in the Quantum Yield of Silicon near 3.5 eV**, Physical Review B, Vol. 42, No. 2, pp. 1262-1267 (15 July 1990).

A broad feature near 3.5 eV was observed in the internal quantum efficiency spectra of various silicon photodiodes. This appears to be the first time this feature has been reported. The feature was clearly resolved in spectra from photodiodes with strong surface fields at the oxide-silicon interface, but was small enough to preclude observation in published spectra for photodiodes with nearly flat-band conditions at the interface. The feature is attributed to a local maximum in the quantum yield for electron-hole pair production that is expected at direct transitions in the vicinity of the Γ point in the silicon BZ. Qualitative arguments suggest that the magnitude of the feature increases with increasing surface field due to field-assisted impact ionization, and in the case of depleted surfaces, also due to band-gap narrowing in the surface depletion region.
[Contact: Jon Geist, (301) 975-2066]

Geist, J., Migdall, A., and Baltes, H., **Shape of the Silicon Absorption Coefficient Spectrum Near 1.63 eV**, Applied Optics, Vol. 29, No. 24, pp. 3548-3554 (20 August 1990).

We report high-precision, high-spectral-resolution measurements of the absorption coefficient of silicon in the region from 1.61 to 1.65 eV. Our results, together with a simulation of the effect of a second indirect transition on the absorption coefficient of silicon, suggest that features reported by Forman et al. (1974) and by Hulthen and Nilsson (1976) around 1.63 eV are not real, and that the second indirect transition in silicon has yet to be detected in absorption coefficient spectra.
[Contact: Jon Geist, (301) 975-2066]

Kohler, R., Luther, J.E., and Geist, J., **Reflectometer for Measurements of Scattering from Photodiodes and Other Low Scattering Surfaces**, Applied Optics, Vol. 29, No. 21, pp. 3130-3134 (20 July 1990).

We have designed and tested a simple instrument to measure the diffuse reflectance of good quality optical surfaces such as the surfaces of semiconductor detectors. Measurements have been performed on silicon-photodiodes and on a sample of known reflectance at two different wavelengths.
[Contact: Jon Geist, (301) 975-2066]

Device Physics & Modeling

Bennett, H.S., and Lowney, J.R., **Physics for Numerical Simulation of Silicon and Gallium Arsenide Transistors**, Solid-State Electronics, Vol. 33, No. 6, pp. 675-691 (1990).

The motivation for using computers to simulate the electrical characteristics of transistors is discussed. Our work and that of others in the area of device physics and modeling is described. We compare conventional device physics with an alternative approach to device physics that is more directly traceable to quantum-mechanical concepts. We then apply this new approach to quasi-neutral regions, space-charge regions, and regions with high levels of carrier injection. The limits for using theoretical results from uniform media in numerical simulations of devices with large concentration gradients are discussed. New calculations of the effective intrinsic carrier concentrations for gallium arsenide and silicon are also given. We conclude with examples of applying quantum-mechanically-based device physics to energy band diagrams for heterojunction bipolar transistors, MOS capacitors, and unirradiated and irradiated homojunction bipolar transistors.
[Contact: Herbert S. Bennett, (301) 975-2053]

Kim, J.S., **A New Method of Extracting the**

Device Physics & Modeling (cont'd.)

Channel Length from the Gate Current of p-Channel MOSFETs [original title: Determining the Channel Length of MOSFET's From the Fowler-Nordheim Tunneling Current], Solid-State Electronics, Vol. 33, No. 8, pp. 1097-1107 (1990).

A new method for determining the channel length of MOSFETs is proposed and experimentally tested. The method is based on the proportionality between the channel area and the body-to-gate current in the Fowler-Nordheim tunneling regime. The new method appears to be superior to two conventionally used techniques, namely, the channel-conductance and the gate-capacitance methods, since it circumvents measurement interferences due to the parasitics encountered in these methods.
[Contact: Jin S. Kim, (301) 975-2238]

Insulators and Interfaces

Kopanski, J.J., **MIS Capacitor Studies on Silicon Carbide Single Crystals: Final Report for May 8, 1989 to November 8, 1989**, NISTIR 4352 (July 1990).

In this continuation of previous work, cubic SiC metal-insulator-semiconductor (MIS) capacitors with thermally grown or chemical-vapor-deposited (CVD) insulators were characterized by capacitance-voltage (C-V), conductance-voltage (G-V), and current-voltage (I-V) measurements. The purpose of these measurements was to determine the four charge densities commonly present in an MIS capacitor (oxide fixed charge, N_f; interface trap level density, D_{it}; oxide trapped charge, N_{ot}; and mobile ionic charge, N_m) and to determine the stability of the device properties with electric field stress and temperature. It was found that an electric field stress would alter the shape of the SiC MIS capacitor C-V characteristics. A negative voltage stress at room temperature would result in a negative shift of the C-V characteristics, indicating the creation of positive charge in the oxide. A positive voltage stress at room temperature resulted in no detectable shift of the C-V curve. The sense of these shifts in the C-V curves is the same as that observed for the "slow trapping" instability often observed in silicon and other semiconductor-based MIS capacitors. From the shift in the C-V characteristics at the midgap point, it was found that a negative voltage stress could increase N_{ot} by as much at 5×10^{11} cm^{-2}. A voltage stress was also found to increase D_{it} by as much as 25%. The mobile ionic charge density was determined from a series of elevated temperature bias stress measurements. N_m for the capacitors in this study ranged from less than 1×10^{11} to 4×10^{11} cm^{-2}. It was found that increasing the temperature would also change the shape of the C-V characteristics, indicating an increase in the number of active interface traps. The resistivity and breakdown field of various insulators on SiC were determined from the I-V characteristics of the capacitors. For capacitors with thermal oxide insulating layers, the average resistivity was about 10^{16} Ω-cm and the average electric breakdown field was 3.3×10^6 V/cm. Fowler-Nordheim tunneling was identified as the charge conduction mechanism for thermal oxide layers on cubic SiC. The barrier height between n-type SiC and SiO_2 for the tunneling of electrons was determined to be 1.8 ± 0.1 eV by fitting the Fowler-Nordheim formula to the observed I-V curve. Finally, some deep-level transient capacitance measurements were attempted on some of the SiC MIS capacitors and on Au on SiC Schottky diodes. In the conclusions of this report, a comprehensive summary of the electrical properties of cubic SiC MIS capacitors is presented.
[Contact: Joseph J. Kopanski, (301) 975-2089]

Miyano, K.E., Kendelewicz, T., Cao, R., Spindt, C.J., Lindau, I., Spicer, W.E., and Woicik, J.C., **Morphology and Barrier-Height Development of Bi/InP(110) Interfaces**, Physical Review B, Vol. 42, No. 5, pp. 3017-3023 (15 August 1990).

Insulators & Interfaces (cont'd.)

The development of the interface between cleaved n- and p-type InP(110) substrates and overlayers of Bi has been studied in the coverage range of 0.01 to 10 monolayers with use of soft-X-ray photoemission spectroscopy. The attenuation and narrowing of the substrate In 4d and P 2p core-level spectra, as well as the lineshape development of the adatom Bi 5d signal, indicate that the morphology is of the Stranski-Krastanov type, as has been verified previously for Sb and Bi overlayers on GaAs(110). Specifically, the Bi grows in ordered two-dimensional patches that merge at one monolayer coverage, and beyond this coverage the deposited adatoms form three-dimensional clusters. The band bending as measured from energy shifts of the In 4d and P 2p spectra approaches midgap near 0.3 monolayer coverage, but between 0.3 and 1.0 monolayer, the band bending for both doping types exhibits a reversal. The reduction in band bending in this deposition regime suggests that some of the submonolayer band bending is induced by states originating at the periphery of the two-dimensional Bi patches. The Bi 5d core-level position provides a local measurement of the surface-Fermi-level position directly beneath these Bi patches: specifically, the absence of Bi 5d shifts suggests that these patches are regions of strong local depletion at coverages as low as 0.01 monolayer. As the three-dimensional Bi clusters develop for depositions exceeding one monolayer, the n- and p-type-surface Fermi-level positions proceed toward 0.75 eV above the valence-band maximum, a position which has been reported for other unreacted metal-InP interfaces. However, the Sb/InP interface, which exhibits a morphology very similar to Bi/InP, gives a barrier height 0.4 eV higher in the gap. Thus, it is observed that the interfacial states at these unreacted and ordered interfaces between such semimetals and InP are strongly dependent on the specific overlayer material.
[Contact: Charles E. Bouldin, (301) 975-2046]

Packaging

Oettinger, F.F., and Blackburn, D.L., **Semiconductor Measurement Technology: Thermal Resistance Measurements**, NIST Special Publication 400-86 (July 1990).

This Special Publication reviews the thermal properties of power transistors and integrated circuits and discusses methods for characterizing these properties. The discrete devices discussed include bipolar transistors and metal-oxide-semiconductor field-effect-transistors. Measurement problems common to these devices, such as deciding the reason a particular measurement is required, adequate reference temperature control, selection of a temperature-sensitive electrical parameter, and separation of electrical and thermal effects during measurement, are addressed. Due to the inherent difficulties in measuring and analyzing the thermal properties of active integrated circuits, an approach using specifically designed thermal test chips for evaluation of new die attachment and packaging schemes is finding wide acceptance in the industry. In this Special Publication, indirect (i.e., electrical) measurements, direct (e.g., infrared) measurements, and computer simulation techniques for thermally characterizing integrated circuits are discussed in terms of their usefulness in characterizing VLSI packages.
[Contact: Frank F. Oettinger, (301) 975-2054]

Other Semiconductor Metrology Topics

Lee, K.C., **The Fabrication of Thin, Freestanding, Single-Crystal, Semiconductor Membranes**, Journal of the Electrochemical Society, Vol. 137, No. 8, pp. 2556-2574 (August 1990).

Freestanding, single-crystal, semiconductor membranes with thicknesses in the range of a few tens of nanometers to tens of microns are of increasing technological interest today. Their applications range from high-speed electronic devices

Other Semiconductor Topics (cont'd.)

to electromechanical devices and pressure sensors. This review paper identifies two general classes of techniques for producing such thin membranes: dissolution of single-crystal wafers and direct growth of single-crystal membranes. Numerous specific techniques in each general class are discussed. The discussion of each technique includes a brief explanation of the reason why it works, a description of the actual experimental implementation, an analysis of the range of thicknesses that can be produced, and the crystalline and electrical quality of the membranes. Unusual difficulties with implementing a technique or special advantages of a technique are also noted. Since this review is intended to aid in the selection of a technique for producing thin semiconductor membranes when one has a particular application in mind, note is made of those applications for which the membranes produced with each technique are particularly well suited.
[Contact: Kevin C. Lee, (301) 975-4326]

Littler, C.L., Zawadzki, W., Loloee, M.R., Song, X.N., and Seiler, D.G., **Phonon-Assisted Magneto-Donor Optical Transitions in n-InSb**, (Proceedings of the International Conference on Narrow-Gap Semiconductors and Related Materials, Gaithersburg, Maryland, June 12-15, 1989), Semicond. Sci. Technol., Vol. 5, No. 3S, pp. S169-S171 (1990).

We have observed and described new optical transitions between magneto-donor states in InSb assisted by optic phonon emission. The phonon-assisted transitions provide a unique opportunity to investigate high excited states of the magneto-Coulomb system. High-resolution data reveal the presence of excited magneto-donor states belonging to the same Landau sub-band.
[Contact: David G. Seiler, (301) 975-2081]

Scace, R.I., **Semiconductor Technology for the Non-Technologist, Second Edition**, NISTIR 4414 (September 1990).

The properties of semiconductor materials, the methods of processing them, and the solid-state products made from them are described in terms intended to be understandable by the lay person. The semiconductor industry has grown at a rate of 17 percent per year compounded for the last thirty years. Its products have declined in unit cost by a factor of 4.7 in current dollars (a factor of 18 in constant dollars) in the same period, irrespective of the vastly increased capabilities of today's products. This very satisfactory but anomalous behavior has attracted the interest of many who are not familiar with the technology of the industry, yet who need to have some understanding of it. This report is intended to help meet that need.
[Contact: Robert I. Scace, (301) 975-2220]

Seiler, D.G., and Littler, C.L., **International Conference on Narrow-Gap Semiconductors and Related Materials, Gaithersburg, MD, June 12-15, 1989** [original title: Narrow Gap Semiconductors: Perspectives and State of the Art], Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 4, pp. 469-481 (July-August 1990).

The Semiconductor Electronics Division at the National Institute of Standards and Technology hosted an International Conference on Narrow-Gap Semiconductors and Related Materials in Gaithersburg, Maryland on June 12-15, 1989. A brief background on narrow-gap semiconductors is given in this paper, along with an overview of the conference itself. The major section of this report is devoted to highlights from each of the invited papers in order to give a perspective on this field of semiconductor research and technology. The Conference Proceedings were published as a special issue of Semiconductor Science and Technology (IOP Publishing, Bristol, 1990).
[Contact: David G. Seiler, (301) 975-2074]

Seiler, D.G., and Littler, C.L., **Narrow-**

Other Semiconductor Topics (cont'd.)

Gap Semiconductors and Related Materials, (Editors), IOP Publishing, Ltd., Bristol, England (1990).

The special characteristics of narrow-gap semiconductors have long been recognized, not only for their interesting physical effects, but also for their technological applications. Such materials are found across a wide range of elements, compounds, and alloys. The International Conference on Narrow-Gap Semiconductors and Related Materials (National Institute of Standards and Technology, Gaithersburg, Maryland) reviewed past research into the physics of both materials and devices, and summarized the present position, in the light of recent rapid developments in the semiconductor field. This major conference, the first of its kind since 1981, drew together 159 delegates from 14 countries. Invited reviews and invited and contributed papers covered II-VI, III-V and IV-VI compounds and various alloys. Topics considered ranged from the characterization of artificially structured materials to the physics of infrared detector devices, as well as a review of high-T_c superconductors for infrared detection; this diversity is reflected in the reviews and papers presented here. This book will be of value to all scientists and engineers interested in narrow-gap semiconductors and needing to keep up to date with the rapid advances in this area.
[Contact: David G. Seiler, (301) 975-2081]

SIGNALS & SYSTEMS METROLOGY PROGRAM

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Bell, B.A., **Standards for Waveform Metrology Based on Digital Techniques**, Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 4, pp. 377-405 (July-August 1990).

Over the last decade, the use of digital synthesis and sampling techniques for generating and measuring electrical waveforms has increased dramatically with the availability of improved digital-to-analog and analog-to-digital converters and related devices. With this evolution has come the need for physical laboratory standards and test methods to support the performance specifications of digital devices and the instruments in which they are used. This article describes the research and development at NIST of several laboratory standards and test systems that utilize "digital technology" for characterizing data converters and for implementing various waveform synthesis and sampling instruments.
[Contact: Barry A. Bell, (301) 975-2419]

Waltrip, B.C., and Oldham, N.M., **Performance Evaluation of a New Audio-Frequency Power Bridge**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 142-143 (1990).

Several techniques for measuring active and reactive power in the 50-Hz to 20-kHz frequency range are described. The approaches include: (1) the development of a high-precision sampling wattmeter using a resistive attenuator, a shunt, and two commercially available sampling voltmeters configured as a dual-channel equivalent-time sampler; (2) the development of another high-precision sampling wattmeter using the same shunt and attenuator, a high-impedance, wideband differential amplifier, and a commercially available, dual-channel, direct-sampling waveform analyzer; (3) for zero power factor measurements, the use of a digital generator to produce precise phase shifts from $+\Pi/2$ to $-\Pi/2$; and (4) the use of simultaneous thermal voltage and current measurements for unity power factor measurements. These approaches were developed to evaluate a new high-accuracy, audio-frequency power bridge that is based on ac voltage and impedance

Waveform Metrology (cont'd.)

measurements.
[Contact: Bryan C. Waltrip, (301) 975-2438]

DC & Low Frequency Metrology

Cage, M.E., Yu, D.Y., Jeckelmann, B.M., Steiner, R.L., and Duncan, R.V., **Investigating the Use of Multimeters to Measure Quantized Hall Resistance Standards**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 332-333 (1990).

A new generation of digital multimeters was used to compare the ratios of the resistances of wire-wound reference resistors and quantized Hall resistances. The accuracies are better than 0.1 ppm for ratios as large as 4:1 if the multimeters are calibrated with a Josephson array.
[Contact: Marvin E. Cage, (301) 975-4248]

Field, B.F., and Oldham, N.M., **Digital Source for a New Impedance Bridge**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 24-25 (1990).

A digitally-synthesized source has been designed to provide two sine wave outputs with an accurately known adjustable phase shift in the second channel for use with a proposed new impedance bridge.
[Contact: Bruce F. Field, (301) 975-4230]

Hamilton, C.A., Burroughs, C.J., and Chieh, K., **Operation of NIST Josephson Array Voltage Standards** [original title: Operation of Josephson-Array Voltage Standards], Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 3, pp. 219-235 (May-June 1990).

This paper begins with a brief discussion of the physical principles and history of Josephson voltage standards. The main body of the paper deals with the practical details of the array design, cryoprobe construction, bias source requirements, adjustment of the system for optimum performance, calibration algorithms, and an assessment of error sources.
[Contact: Clark A. Hamilton, (303) 497-3740]

Kinard, J.R., Huang, D.X., and Novotny, D.B., **Hybrid Construction of Multijunction Thermal Converters**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 62-63 (1990).

Using thin-film and thick-film technologies, multijunction thermal converters have been designed for frequencies ranging from audio up to tens of megahertz and for heater currents from a few milliamperes up to hundreds of milliamperes. This paper describes these designs and the early production of prototype converters.
[Contact: Joseph R. Kinard, (301) 975-4250]

Kinard, J.R., Huang, D.X., and Rebuldela, G., **RF-DC Differences of Thermal Voltage Converters Arising from Input Connectors**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 280-281 (1990).

The radiofrequency-dc differences of thermal voltage converters caused by skin effect and transmission line effects of different length input structures have been previously studied. Discrepancies do exist, however, between simple mathematical models and measured results for commonly used input connectors. This paper reports a study of these discrepancies.
[Contact: Joseph R. Kinard, (301) 975-4250]

Kinard, J.R., Lipe, T.E., and Childers, C.B., **AC-DC Difference Relationships for Current Shunt and Thermal Converter**

DC & Low Frequency Metrology (cont'd.)

Combinations, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 136-137 (1990).

This paper describes the relationship between the overall ac-dc difference of a thermal converter and current shunt combination and the characteristics of the separate thermal converter and current shunt. As a consequence of the analysis, an expression predicting the ac-dc difference of a thermal converter/-shunt combination when thermoelements are interchanged is presented, and data illustrating the agreement between values of ac-dc difference and values predicted by the analysis are given.
[Contact: Joseph R. Kinard, (301) 975-4250]

Oldham, N.M., and Henderson, R.M., **New Low-Voltage Standards in the DC to 1 MHz Frequency Range**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 66-67 (1990).

Several new techniques for measuring the rms value of 1- to 200-mV signals have been developed and compared to existing techniques using thermal transfer standards. Differences between the various measurement methods at 100 mV are typically within ±100 parts per million from dc to 1 MHz.
[Contact: Nile M. Oldham, (301) 975-2408]

Steiner, R.L., and Astalos, R.J., **Improvements for Automating Voltage Calibrations Using a 10-V Josephson Array**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 102-103 (1990).

With three novel improvements, a voltage standard system based on a 10-V Josephson array is totally automated. A commercial standard cell scanner controls switching for calibrating either Zener references or digital voltmeters, a programmable attenuator helps in obtaining voltage steps, and measurements of DVM noise help in verifying array stability.
[Contact: Richard Steiner, (301) 975-4226]

Fundamental Electrical Measurements

Olsen, P.T., Tew, W.L., Elmquist, R.E., and Williams, E.R., **Monitoring the Mass Standard: A Comparison of Mechanical to Electrical Power**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 180-181 (1990).

Except for the kilogram, all of the base units of the International System of Units (SI) are defined by invariant fundamental constants. The on-going NIST absolute watt experiment shows the promise of being able to monitor the stability of the mass standard to better than 0.05 ppm. We discuss our latest results and future possibilities.
[Contact: P. Thomas Olsen, (301) 975-6553]

Cryoelectronic Metrology

Hamilton, C.A., Burroughs, C.J., and Chieh, K., **Operation of NIST Josephson Array Voltage Standards** [original title: Operation of Josephson-Array Voltage Standards], Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 3, pp. 219-235 (May-June 1990).

This paper begins with a brief discussion of the physical principles and history of Josephson voltage standards. The main body of the paper deals with the practical details of the array design, cryoprobe construction, bias source requirements, adjustment of the system for optimum performance, calibration algorithms, and an assessment of error sources.
[Contact: Clark A. Hamilton, (303) 497-3740]

Martinis, J.M., and Ono, R.H., Fabrica-

Cryoelectronic Metrology (cont'd.)

tion of Ultrasmall Nb-AlO_x-Nb Josephson Tunnel Junctions, Applied Physics Letters, Vol. 57, No. 6, pp. 629-631 (6 August 1990).

We describe a fabrication process to make Nb-AlO_x-Nb edge junctions with areas down to 0.0022 μm^2 and with current densities from 10 to 24000 A/cm^2. The junction conductance was low for voltages below the superconducting energy gap, indicating good quality tunnel barriers. Coulomb gap measurements obtained when the junctions were in the normal state were used to find the junction capacitance. Junction capacitance as small as 0.18 fF has been measured.
[Contact: John M. Martinis, (303) 497-3597]

Pulse Power Metrology

FitzPatrick, G.J., Olthoff, J.K., Simmon, E.D., and Fenimore, Jr., C.P., **Metrology for Space Power: Metrology Development and Survey of Space-Based Measurements**, NISTIR 4422 (September 1990).

This report documents technical progress in the three investigations comprising the project "SDI Measurement Techniques" funded by the Strategic Defense Initiative Office. The first investigation assesses the applicability of magneto-optic sensors for measuring submicro-second-risetime current pulses. The results of comparative measurements with fiber optic current sensors and conventional detectors are reported. The optical sensors have sufficient bandwidth, but sensor stability is a problem, especially for remote applications. The second investigation develops part of the mathematical background needed for assessing the reliability and efficiency of diagnostics used in the development and deployment of pulsed power components and systems. Through comparative measurements, characteristic signatures of nonlinearities in an electro-optic voltage measurement system of the order of 1% in magnitude have been detected. Nonlinearities in a conventional detector have been investigated through appropriate models. The third investigation involves the accumulation of existing information necessary to support an effective measurement development program. The results of an in-depth study of existing space-based measurement techniques are reported, and the findings indicate that present space-based measurement systems are inadequate for anticipated SDI requirements.
[Contact: Gerald J. FitzPatrick, (301) 975-2737]

Antenna Metrology

Hill, D.A., **Electric and Magnetic Dipole Radiation in a Random Medium**, Electromagnetics, Vol. 10, pp. 279-292 (1990). (Previously published as Sections 4 and 5 of NISTIR 89-3909.)

Electric and magnetic dipole radiation are studied for a medium where random, small-scale inhomogeneities are confined to a spherical shell region. Numerical results are presented for both the far-field pattern and the total radiated power. When the random inhomogeneities are located in the near field of the source, an electric dipole radiates a larger incoherent field than a magnetic dipole because of its larger reactive electric field.
[Contact: David A. Hill, (303) 497-3472]

Microwave & Millimeter-Wave Metrology

Kinard, J.R., Huang, D.X., and Novotny, D.B., **Hybrid Construction of Multijunction Thermal Converters**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 62-63 (1990).

Using thin-film and thick-film technologies, multijunction thermal converters have been designed for frequencies ranging from audio up to tens of megahertz and for heater currents from a few milliamperes up to hundreds of milliamperes. This paper describes these

Microwave & Millimeter-Wave (cont'd.)

designs and the early production of prototype converters.
[Contact: Joseph R. Kinard, (301) 975-4250]

Kinard, J.R., Huang, D.X., and Rebuldela, G., **RF-DC Differences of Thermal Voltage Converters Arising from Input Connectors**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 280-281 (1990).

The radiofrequency-dc differences of thermal voltage converters caused by skin effect and transmission line effects of different length input structures have been previously studied. Discrepancies do exist, however, between simple mathematical models and measured results for commonly used input connectors. This paper reports a study of these discrepancies.
[Contact: Joseph R. Kinard, (301) 975-4250]

Optical Fiber Metrology

Day, G.W., and Franzen, D.L., (Editors), **Technical Digest -- Symposium on Optical Fiber Measurements, 1990**, NIST Special Publication 792 (September 1990).

This digest contains summaries of 46 papers presented at the Symposium on Optical Fiber Measurements, held September 11-12, 1990, at the National Institute of Standards and Technology, Boulder, Colorado. Paper titles: Industry standard measurements: a user's perspective; COST 217 interlaboratory comparison of optical measurements on single-mode fiber couplers; COST 217 mode field diameter measurements intercomparison; Post-mortem analysis of optical fibers; Optical frequency domain reflectometry using network analysis techniques; Long and short range measurements using coherent frequency-modulated, continuous-wave reflectometry; Very low optical return loss measurement using optical time-domain reflectometry technique; Comparison between optical time-domain reflectometry and optical low-coherence reflectometry (OLCR) with micrometer spatial resolution: new improved OLCR detection scheme and latest measurement results on IOC; Multiphoton pulse approach in photon-timing optical time-domain reflectometry yields enhanced dynamic range and shorter measurement time; Characterization of hydrogen diffusion in hermetically coated optical fibers; The anomalous structure observed in single-mode fiber cutoff wavelength measurements: theory and solutions; A recent advance in the measurement of the refractive index profile of optical fiber preforms; Refractive index measurements on single-mode fiber as functions of product parameters, tensile stress and temperature; Spatially resolved measurement of high attenuation in integrated optical polarizers; Waveguide loss and effective indices determination by optical frequency scan of integrated resonant cavities.

Measurement of mode indices of channel waveguides by interferometry; Comparison of time and frequency domain measurement methods for high speed optical modulators; Characterization of the dynamic response of a waveguide phase modulator by means of an optical frequency discriminator; Fiber discriminator measurements of phase modulation in an integrated Mach-Zehnder intensity modulator; Characterization of erbium-doped fiber amplifiers; Measurement of the spectral dependence of absorption cross section for erbium-doped single-mode optical fiber; Wavelength characterization of components for optical networking applications in the 1.5-μm transmission window; Measurement of laser diode intensity noise below the shot noise limit; An optical synthesizer with sinusoidal-modulated Michelson interferometer for generation of an absolutely stabilized carrier frequency comb; Characterization of high birefringence fiber for sensor applications; Interpretation of polarization dispersion in a single-mode fiber; Polarization mode dispersion of short and long single-mode

Optical Fiber Metrology (cont'd.)

fibers; Distributed strain measurements in optical fibers using Brillouin optical-fiber time domain analysis; Standards for optical fiber geometry measurements; A comparison of interferometric techniques for fiber cladding diameter measurements.

Accurate determination of cladding diameter and noncircularity of optical fibers; Calibration of fiber diameter measurements; Fiber geometry measurement and quality of parameter estimation; Pulse-delay measurement for long zero-dispersion fibers; Measurement of reduced germania (GeO) defect levels in optical fibers by fluorescence and absorption spectroscopy; Standardized measurements for determining the radiation-induced attenuation in optical fibers; Test method for fiber optic connector parameters directly affecting return loss; Differentiating core and cladding loss contributions in single mode fiber attenuation measurements; A single launch technique to determine loss and dispersion in multimode fiber systems; Measurement of fiber coating geometry using a transversely scanning laser beam; Reliability testing of a fiber optic system for subscriber loop applications; Accurate modal characterization of passive components based on selective excitation of optical fibers; The modulation transfer function for coupling components; Low reflectance, in-line, continuously variable attenuator for lightwave systems characterization; and Photorefractive intermodal exchangers (PRIME) in optical fiber: theory and applications.
[Contact: Gordon W. Day, (303) 497-5204]

Optical Fiber Sensors

FitzPatrick, G.J., Olthoff, J.K., Simmon, E.D., and Fenimore, Jr., C.P., **Metrology for Space Power: Metrology Development and Survey of Space-Based Measurements**, NISTIR 4422 (September 1990).

This report documents technical progress in the three investigations comprising the project "SDI Measurement Techniques" funded by the Strategic Defense Initiative Office. The first investigation assesses the applicability of magneto-optic sensors for measuring submicro-second-risetime current pulses. The results of comparative measurements with fiber optic current sensors and conventional detectors are reported. The optical sensors have sufficient bandwidth, but sensor stability is a problem, especially for remote applications. The second investigation develops part of the mathematical background needed for assessing the reliability and efficiency of diagnostics used in the development and deployment of pulsed power components and systems. Through comparative measurements, characteristic signatures of nonlinearities in an electro-optic voltage measurement system of the order of 1% in magnitude have been detected. Nonlinearities in a conventional detector have been investigated through appropriate models. The third investigation involves the accumulation of existing information necessary to support an effective measurement development program. The results of an in-depth study of existing space-based measurement techniques are reported, and the findings indicate that present space-based measurement systems are inadequate for anticipated SDI requirements.
[Contact: Gerald J. FitzPatrick, (301) 975-2737]

Electro-Optic Metrology

Larson, D.R., and Phelan, Jr., R.J., **Hydrogenated Amorphous Germanium Detectors Deposited onto Channel Waveguides**, Optics Letters, Vol. 15, No. 10, pp. 544-546 (May 15, 1990).

We have fabricated hydrogenated amorphous germanium photodetectors coupled to channel waveguides in glass and lithium niobate substrates. We measured a pulse response duration of 140 psec (full width at half maximum), which is shorter than that of any previously reported photodetectors deposited onto dielectric

Electro-Optic Metrology (cont'd.)

waveguides. The optical gap, which determines the spectral response characteristics, is approximately 1.2 eV. We have measured a photoconductive gain of 18 in phosphorus-doped detectors.
[Contact: Donald R. Larson, (303) 497-3440]

Other Fast Signal Topics

Bell, B.A., Perrey, A.G., and Treado, M.J., **Evaluation of Hands-Free Communication Systems**, NISTIR 90-4230 (August 1990).

Hands-Free Communication Systems (HFCS) are used by law enforcement agencies, fire departments, rescue squads, and the Armed Forces, where tasks require the communications operator's hands to be free. Four such HFCSs were tested to measure their operational characteristics of voltage gain/frequency response, signal-to-noise ratio, total harmonic distortion, and sensitivity.
[Contact: Barry A. Bell, (301) 975-2402]

Capobianco, T.E., **Eddy Current Probe Characterization Using an Impedance Plane Display Instrument** [original title: Using an Eddy Current Impedance Plane Display Instrument for Probe Characterization], Proceedings of the 38th Defense Conference on Nondestructive Testing (NDT), San Antonio, Texas, October 31-November 2, 1989, pp. 193-201 (1990).

The U.S. Army is sponsoring work at the National Institute of Standards and Technology to develop a military standard for characterizing the performance of eddy-current probes for nondestructive testing. Presently, the test method of this draft standard constitutes a measurement of the change in probe impedance when the probe is applied to test blocks of two different conductivities. It was hoped that this impedance measurement would be easy to perform in the field, but we discovered that field and depot level operations lack the equipment for measuring impedance, a serious obstacle to the implementation of the standard. However, depot operations often have an eddy-current instrument which displays flaw signals in the impedance plane. These instruments do not display the actual impedance values for the flaw signals, but could possibly be calibrated for this purpose. Results are presented of an experiment where a calibration technique was tried and eddy-current probe impedances measured. The calibration technique consists of using a switchable combination of resistors and inductors to produce reference points on the display of the impedance-plane instrument. The impedance measurements were made by interpolating values from these reference points for flaw signals obtained when the probes were scanned over an electrical discharge machined notch in 6061-T651 aluminum.
[Contact: Thomas E. Capobianco, (303) 497-3141]

Fulcomer, P.M., **Prospects for the Use of Lithium Batteries in Law Enforcement Equipment**, National Institute of Justice Technology Assessment Report, NIJ Report 201-89 (April 1990).

Lithium batteries have been available for a number of years, mainly in primary type (nonrechargeable), low-current-drain configurations (i.e., less than 10 mA). Within the past several years, more medium-to-high-current drain (50- to 500-mA) lithium primary cells have become available, and within the past few years lithium secondary cells (rechargeable) have been introduced. The advantages of lithium include better low-temperature performance and much longer shelf life for primary cells, and superior charge retention and lack of a memory effect for secondary cells. Both types can provide significantly more power per volume and per weight than equivalent nonlithium batteries. In addition to the advantages and disadvantages of lithium batteries and their applicability for use in law enforcement equipment, this report discusses lithium battery background, the

Other Fast Signal Topics (cont'd.)

safety precautions required in the use of lithium cells, and the battery requirements for present law enforcement equipment. The report concludes that the use of lithium batteries would be beneficial to the operation of most battery-operated equipment used by law enforcement personnel. To fully realize the advantages mentioned above, however, and to minimize the effect of their higher initial cost, lithium batteries should, with two exceptions, be designed into new equipment.
[Contact: P. Michael Fulcomer, (301) 975-2407]

ELECTRICAL SYSTEMS

Power Systems Metrology

Fenimore, C., Stricklett, K.L., Yamashita, H., Kawai, H., Forster, E.O., and Pompili, M., **The Inception and Structure of Prebreakdown Streamers in Perfluorinated Polyethers**, Conference Record of the Tenth International Conference on Conduction and Breakdown in Dielectric Liquids, Grenoble, France, September 10-14, 1990, pp. 430-435 (September 1990).

One member of a family of materials, the perfluorinated polyethers, is subjected to electrical measurements to determine its suitability as a liquid dielectric. Measures of the breakdown strength and streamer inception voltage are obtained under electrical impulse stress. The breakdown strength is nearly independent of polarity. Under high magnification photography, the cathode-originated streamers are seen to have a subsonic mode of growth. The transition to fast growth occurs on time and spatial scales shorter than those reported in liquid hydrocarbons. The gas phase electrical properties and the high heat of vaporization of this material are considered as mechanisms for this behavior.
[Contact: Charles Fenimore, (301) 975-2428]

Filipski, P.S., Moore, W.J.M., Knight, R.B.D., Martin, P., and Oldham, N.M., **An International Comparison of Low Audio Frequency Power Meter Calibrations Conducted in 1989**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 158-159 (1990).

The results of an intercomparison of low-audio-frequency power meter calibrations conducted in 1989 between the National Research Council (NRC), Canada, the National Physical Laboratory (NPL), United Kingdom, and the National Institute of Standards and Technology (NIST), USA, are described. A time-division watt-converter, developed at NRC, was used as the transfer standard. The measurements were made at 120 V, 5 A, power factors of 1, 0 lead, and 0 lag and at frequencies up to 5 kHz. Agreement between the NPL and NRC laboratories was better than 63 ppm in the 60- to 1600-Hz range, and 74 ppm between NIST and NRC in the 50- to 4800-Hz range.
[Contact: Nile M. Oldham, (301) 975-2408]

Oldham, N.M., Laug, O.B., Waltrip, B.C., and Palm, R.H., **The NIST Digitally Synthesized Power Calibration Source**, NIST Technical Note 1281 (August 1990).

A digitally synthesized source of "phantom" power for calibrating electrical power and energy meters is described. Independent sources of voltage, current, and phase angle are programmable between 0 to 240 V, 0 to 5 A, and 0 to 360 deg, respectively. The uncertainty of the active and reactive power is estimated to be within ±100 ppm of the full-scale apparent power (volt-amperes).
[Contact: Nile M. Oldham, (301) 975-2408]

Ramboz, J.D., Fenimore, C., and Schiller, S.B., **Qualifying Watthour Meters for Use as MAP Transport Standards**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 329-330 (1990).

Power Systems Metrology (cont'd.)

The NIST Measurement Assurance Program (MAP) transfers the watthour using transport meters. A statistical design is employed to determine the linear and nonlinear corrections for the response of each meter to varying conditions of voltage, current, temperature, and power factor. For applications requiring lower precision, a heuristic for dropping correction terms is given.
[Contact: John D. Ramboz, (301) 975-2434]

Ramboz, J.D., and West, J.L., **Watt Transfer Standard**, Digest of the 1990 Conference on Precision Electromagnetic Measurements, Ottawa, Canada, June 11-14, 1990, pp. 160-161 (1990).

The use of a time-division multiplier power meter as a watt transfer standard between the National Institute of Standards and Technology (NIST) and an industry standards laboratory is described. Measurements of power at 120 and 240 V, 5 A, 50 and 62 Hz, and power factors of 1 and 0 lagging are described. After the unit of power was transferred to the industrial laboratory, a comparison of the laboratory and NIST calibrations indicated an agreement to within 14 parts per million.
[Contact: John D. Ramboz, (301) 975-2434]

Stricklett, K.L., Kelley, E.F., Yamashita, H., Fenimore, C., Pace, M.O., Blalock, T.V., Wintenburg, A.L., and Alexeff, I., **Observations of Partial Discharges in Hexane Under High Magnification**, Conference Record of the Tenth International Conference on Conduction and Breakdown in Dielectric Liquids, Grenoble, France, September 10-14, 1990, pp. 381-386 (September 1990).

Partial discharges are observed in hexane by shadow photography under the application of dc voltages. A nonuniform field geometry is employed, and the growth of low-density streamers at a point cathode is recorded. Photographs of the partial discharge streamers are obtained at 200X magnification. The use of an image-preserving optical delay allows a record of the conditions which exist in the liquid prior to the initiation of the low-density streamer to be obtained. A concurrent record of the partial discharge current is obtained. Analysis of these data indicates that electrostatic forces are adequate to describe streamer growth.
[Contact: Kenneth L. Stricklett, (301) 975-3955]

Yamashita, H., Kawai, H., Stricklett, K.L., and Kelley, E.F., **The Effect of High Pressure on Prebreakdown Phenomena in N-Hexane**, Conference Record of the Tenth International Conference on Conduction and Breakdown in Dielectric Liquids, Grenoble, France, September 10-14, 1990, pp. 404-409 (September 1990).

The effect of pressure on the initiation of prebreakdown streamers at a point cathode in n-hexane is investigated. Using a high-magnification (100X) high-resolution (1-μm) optical system and a high-speed camera, the initial growth of low-density streamers at pressures ranging from 0.1 to 1.1 MPa is examined. The initial streamer appears to be a single filament 4.1 $\pm$ 2.1 μm in length. The streamer initiation voltage is shown to increase with pressure and the rate of collapse of the streamer is faster at high pressure.
[Contact: Hisanao Yamashita, (301) 975-5826

Superconductors

Bray, S.L., and Goodrich, L.F., Current **Supply for High-T_c Superconductor Testing** [original title: High-T_c Current Supply for DC Critical-Current Measurements], Measurement Science Technology, Vol. 1, pp. 491-494 (1990).

Precise and accurate measurements of the dc critical current of high T_c superconductors often require a current supply that has high stability and low output ripple. A design for a simple and

Superconductors (cont'd.)

inexpensive current supply that has these characteristics is presented. The primary power source for this supply is a 12-V wet-cell battery. The typical operating range of the current supply is from 10 mA to 10 A. The performance of the supply with respect to current ripple, stability, and linearity is reported.
[Contact: Steven L. Bray, (303) 497-5631]

Collings, E.W., Marken, Jr., K.R., Sumption, M.D., Goldfarb, R.B., and Loughran, R.J., **AC Loss Measurements of Two Multifilamentary NbTi Composite Strands**, Advances in Cryogenic Engineering (Materials), Vol. 36, pp. 169-176 (1990).

As part of an interlaboratory comparative testing program conducted in support of the Versailles Agreement on Advanced Materials and Standards (VAMAS), transverse-field dc hysteresis loss measurements were made at liquid-helium temperatures at fields of up to 3 T (30 kG) on two samples of multifilamentary NbTi composite. The strands differed widely in filament number, were comparable in filament diameter, and one of them was provided with a Cu-Ni barrier between the filaments. The results have been analyzed, and magnetically deduced critical current density values obtained (for comparison with directly measured transport data) using various standard techniques. Based on these studies, a figure-of-merit for ac loss is recommended. The Cu-matrix strand, with its interfilamentary spacing of less than 1 μm, exhibited pronounced proximity-effect-induced coupling losses; this was not observed in the mixed-matrix strand which possessed not only a Cu-Ni barrier but also an interfilamentary spacing of typically 4 μm.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Ekin, J.W., Hart, Jr., H.R., and Gaddipati, A.R., **Transport Critical Current of Aligned Polycrystalline $Y_1Ba_2Cu_3O_{7-\delta}$ and Evidence for a Nonweak-Linked Component of Intergranular Current Conduction**, J. Appl. Phys., Vol. 68, No. 5, pp. 2285-2295 (1 September 1990).

A study of grain alignment and its effect on the dc transport critical current in fine-grained bulk $Y_1Ba_2Cu_3O_{7-\delta}$ is reported in magnetic fields from 10^{-4} T to 26 T. Two features distinguish the critical-current density J_c of aligned bulk $Y_1Ba_2Cu_3O_{7-\delta}$ from unaligned material. First, the effective critical field where the intergranular J_c approaches zero is about four times higher (30 T) for aligned samples with field parallel to the a, b planes, than it is for polycrystalline unaligned samples (7 T). Second, the nearly field-independent plateau value of J_c between 10 mT and 1 T is one to two orders of magnitude higher than typical plateau values of J_c in unaligned bulk-sintered $Y_1Ba_2Cu_3O_{7-\delta}$, for field parallel to the a, b planes. A low-field (<10-mT) weak-link decrease in J_c with magnetic field is still observed, but it is much smaller than for unaligned material. These data clearly demonstrate that alignment alone significantly reduces the weak-link problem in fine-grained polycrystalline samples with low-aspect-ration (4:1) grains (unlike melt-grown samples where there has been some ambiguity as to the relative importance of alignment versus large grain growth). Furthermore, the results provide strong evidence that there are two parallel components of intergranular current conduction, one consisting of weak-linked material, the other behaving like intrinsic intragranular material that is not weak-linked. A comparison with unaligned $Y_1Ba_2Cu_3O_{7-\delta}$ indicates that the volume fraction of such nonweak-linked material is significantly enhanced by grain alignment, but still only 0.01% to 0.1% of the grain boundary area. Field-cooled and force-free J_c data are also presented, along with detailed measurements of the shapes of the voltage-current characteristics.
[Contact: John W. Ekin, (303) 497-5448]

Superconductors (cont'd.)

Goldfarb, R.B., and Ishida, T., **Fundamental and Harmonic Susceptibilities of $YBa_2Cu_3O_{7-\delta}$**, Physical Review B, Vol. 41, No. 13, pp. 8937-8948 (1 May 1990).

We have examined the complex harmonic magnetic susceptibilities $\chi_n = \chi_n' - i\chi_n''$ ($n = 1, 2, 3, \ldots, 10$) of the sintered high-critical-temperature superconductor $YBa_2Cu_3O_{7-\delta}$ (YBCO). The experimental variables for the measurements of χ_n were the sample temperature ($10 \leq T \leq 110$ K), the ac magnetic field amplitude H_{ac} ($1.4\ \mu T \leq \mu_0 H_{ac} \leq 8.5$ mT) and frequency f ($7.3 \leq f \leq 1460$ Hz), and the magnitude of a superimposed dc field H_{dc} ($0 \leq \mu_0 H_{dc} \leq 8.5$ mT). As functions of temperature, χ_1' and χ_1'' depend on both H_{ac} and H_{dc}. In particular, the χ_1' transition curve may shift to higher temperatures with increasing H_{dc}. Odd-harmonic susceptibilities were measured as functions of temperature below T_c for zero H_{dc}; both even and odd harmonics were observed for nonzero H_{dc}. The temperature dependence of χ_3 is a strong function of H_{ac}. $|\chi_3|$ has a maximum below the critical temperature T_c, similar to the peak in χ_1'', which is slightly frequency dependent. At fixed temperature, the odd-harmonic susceptibilities are even functions of H_{dc}, while the even-harmonic susceptibilities are odd functions of H_{dc}. We compared the experimental intergrain coupling characteristics of χ_n' and χ_n'' with theoretical susceptibility curves based on magnetization equations derived by Ji et al. from a simplified Kim model for critical current density. The theoretical curves are in good agreement with the temperature- and field-dependent features of χ_n' and χ_n'', and thus, the intergrain coupling component of a sintered high-T_c superconductor has the properties of a type-II superconductor.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Goldfarb, R.B., and Spomer, R.L., **Magnetic Characteristics and Measurements of Filamentary Nb-Ti Wire for the Superconducting Super Collider**, Advances in Cryogenic Engineering (Materials), Vol. 36, pp. 215-222 (1990).

In synchrotron accelerator applications, such as the superconducting super collider (SSC), superconducting magnets are cycled in magnetic field. Desirable properties of the magnets include field uniformity, field stability with time, small residual field, and fairly small energy losses upon cycling. This paper discusses potential sources of problems in achieving these goals, describes important magnetic characteristics to be considered, and reviews measurement techniques for magnetic evaluation of candidate SSC wires. Instrumentation that might be practical for use in a wire-fabrication environment is described. We report on magnetic measurements of prototype SSC wires and cables and speculate on causes for instability in multipole fields of dipole magnets constructed with such cables.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Goodrich, L.F., and Bray, S.L., **High-T_c Superconductors and the Critical Current Measurement**, Cryogenics, Vol. 30, pp. 667-677 (August 1990).

With the introduction of high-T_c superconductors, a number of problems associated with the critical-current (I_c) measurement has arisen. The existing I_c measurement practices have been developed and proven for low-T_c superconductors. There are substantial differences between the two classes of materials. When the I_c concept was casually extended to the high-T_c conductors, the problems of measurement inconsistency, ambiguity, and in some cases, invalidity followed. A discussion of the underlying philosophy of the I_c measurement is presented. Also, a number of measurement variables that can influence the measured I_c are discussed. Many of the problems stem from inadequate I_c reporting practices. Recommendations are given for improving I_c measurement reports.
[Contact: Loren F. Goodrich, (303) 497-3143]

Superconductors (cont'd.)

Tan, Z., Budnick, J.I., Bouldin, C.E., Woicik, J.C., Cheong, S-W., Cooper, A.S., Espinosa, G.P., and Fisk, Z., **Polarization X-ray Absorption Near-Edge Structure Study of $Pr_{2-x}Ce_xCuO_4$ Single Crystals: The Nature of Ce Doping**, Physical Review B, Vol. 42, No. 1, pp. 1037-1040 (1 July 1990).

A polarization Cu K-edge x-ray absorption near-edge structure (XANES) study has been carried out on $Pr_{2-x}Ce_xCuO_4$ single crystals. The spectra for X-ray polarization vector **E** nearly parallel to the crystal c-axis suggest that electrons contributed by Ce doping are initially localized at the Cu site. The spectra for **E** perpendicular to the c-axis exhibit an almost rigid edge shift to lower energie upon Ce doping. This suggests that the unoccupied in-plane Cu 4p states shift to lower energies. Therefore, the Ce doping donates electrons to the Cu site and also shifts the unoccupied 4p band. We propose that the upper unoccupied band consisting of predominately Cu 3d states shifts downward and eventually joins the initially localized states near the Fermi level and thus, forms the conduction band in the n-type superconductor.
[Contact: Charles E. Bouldin, (301) 975-2046]

Magnetic Materials & Measurements

Goldberg, I.B., Mitchell, M.R., Murphy, A.R., Goldfarb, R.B., and Loughran, R.J., **Magnetic Susceptibility of Inconel Alloys 718, 625, and 600 at Cryogenic Temperatures**, Advances in Cryogenic Engineering (Materials), Vol. 36, pp. 755-762 (1990).

In June 1988, the Discovery Space Shuttle mission was delayed because of a malfunctioning hydrogen fuel bleed valve system. The problem was traced to the linear variable differential transformer (LVDT) which produced erroneous readings for the valve position. Near liquid hydrogen temperatures, the inconel used in the armature of the LVDT became magnetic. The alternating current magnetic susceptibility of three samples of inconel 718, that differed slightly in composition, and one sample of inconel 625 were measured as a function of temperature. Inconel 718 behaves as a spin glass. Its susceptibility reaches a maximum between 15 and 19 K, near the liquid hydrogen boiling point, 20 K. The magnitude of the susceptibility changed by an order of magnitude with decreases of 1.2% in iron and 1.5% in nickel. The nominal composition is 12 to 20% iron and 50 to 55% nickel. Inconel 625, which contains about 4% iron, was paramagnetic. The qualitative behavior of these materials follows trends indicated by Chauvenard (1928) and Jackson and Russell (1938).
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Moreland, J., and Rice, P., **High-Resolution, Tunneling-Stabilized Magnetic Imaging and Recording**, Applied Physics Letters, Vol. 57, No. 3, pp. 310-312 (16 July 1990).

A scanning tunneling microscope (STM) has been used to image and record magnetic regions on the surface of a computer hard disk. The usual rigid STM tip was replaced by a compliant magnetized Fe film tip. As a result, tunneling images were combinations of the surface topography and variations in the magnetic force between the Fe film tip and the disk surface. We believe that the recording process relied on maintaining the close proximity of a magnetized Fe film tip near the disk surface. Apparently, the magnetic field was focused near the Fe film tip with sufficient intensity to change the surface magnetization of the disk. We have recorded spots on the disk within a 500 by 500 nm^2 area. These spots were subsequently imaged with the same STM tip. Our best magnetic image resolution was 20 nm. The compliance of the Fe film tips was such that image contrast due to variation of the magnetic force on the Fe film tip corresponded to z-motion piezoelectric elongations as

Magnetic Materials & Meas. (cont'd.)

large as 50 nm.
[Contact: John Moreland, (303) 497-3641]

Peterson, R.L., **Magnetization of Anisotropic Superconducting Grains**, Journal of Applied Physics, Vol. 67, No. 11, pp. 6930-6933 (1 June 1990).

A critical-state calculation of the magnetization of hard type-II superconducting grains having anisotropic critical-current densities is given. The grains are assumed to present rectangular cross sections to an applied magnetic field. The analysis shows how the critical-current densities should be inferred from magnetization measurements for various grain dimensions. For grains in the form of platelets, the hysteresis changes with grain size. However, for very elongated grains with anisotropic critical currents, such as may be found in the high-temperature superconductors, the magnetic hysteresis is insensitive to the lengths of the grains, and hence to powdering.
[Contact: Robert L. Peterson, (303) 497-3750]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

Hill, D.A., **Electric and Magnetic Dipole Radiation in a Random Medium**, Electromagnetics, Vol. 10, pp. 279-292 (1990). (Previously published as Sections 4 and 5 of NISTIR 89-3909.)

Electric and magnetic dipole radiation are studied for a medium where random, small-scale inhomogeneities are confined to a spherical shell region. Numerical results are presented for both the far-field pattern and the total radiated power. When the random inhomogeneities are located in the near field of the source, an electric dipole radiates a larger incoherent field than a magnetic dipole because of its larger reactive electric field.
[Contact: David A. Hill, (303) 497-3472]

ADDITIONAL INFORMATION

Lists of Publications

Lyons, R.M., and Gibson, K.A., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 3945 (August 1990).

This bibliography lists publications by the staff of the National Institute of Standards and Technology's Electromagnetic Fields Division for the period from January 1970 through August 1989. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Kathryn A. Gibson, (303) 497-3132]

DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications**, NISTIR 89-3921 (August 1989).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NIST in the period from January 1970 through publication of this report. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Sarabeth Moynihan, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publications 94** (January 1990).

This bibliography covers publications of the Electricity Division, Center for Electronics and Electrical Engineering, NIST, and of its predecessor sections for the period January 1968 to December 1989. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Additional Information (cont'd.)

Walters, E.J., **Semiconductor Measurement Technology, NIST List of Publications 72** [a bibliography of NIST publications concerning semiconductor measurement technology for the years 1962-1989] (March 1990).

This bibliography contains reports of work performed at the National Institute of Standards and Technology in the field of Semiconductor Measurement Technology in the period from 1962 through December 1989. An index by topic area and a list of authors are provided.
[Contact: E. Jane Walters, (301) 975-2050]

NEW CALIBRATION SERVICES OFFERED

The explosive growth of optical fiber use in the communications industry has resulted in a demand for calibration services. NIST's Boulder, Colorado, laboratory now offers **measurements of optical laser power and energy at wavelengths and power levels of interest to fiber optic producers and users.** Measurements are based on a standard reference instrument called the C-series calorimeter. An electrically calibrated pyroelectric radiometer (ECPR) is calibrated against the calorimeter and is then used to calibrate optical power meters at wavelengths of 850, 1300, and 1550 nm. To improve calibration capabilities, NIST is preparing test measurement systems for detector linearity, detector uniformity, and detector spectral responsivity. These systems should be available in 6 months. For a paper outlining NIST's optical power measurement capabilities, contact Fred McGehan, Div. 360, NIST, 325 Broadway, Boulder, Colorado 80303. For more information on calibration services, contact Thomas R. Scott, Div. 724, same address, or phone (303) 497-3651.

NEW NIST RESEARCH MATERIAL

NIST has announced the availability of **Research Material 8458**, a well-characterized artificial flaw used as an **artifact standard in eddy current nondestructive evaluation (NDE).** The new Research Material (RM) is the outcome of work carried out by the Division to address the need for calibration standards for eddy-current NDE, for example as used to detect fatigue cracks in aircraft structures. The RM flaw is produced in an annealed aluminum alloy block by first indenting the block and then compressively deforming the resulting notch until it is tightly closed. The next operation is to restore a flat finish to the block face, after which the block is heat treated to the original temper. The controlled flaw has been named the "CDF notch," after its inventors (listed on patent application) Thomas E. Capobianco (Electromagnetic Technology Division), William P. Dube (Division 583), and Ken Fizer (Naval Aviation Depot, NAS Norfolk, Virginia).

In the past, the challenge has been to manufacture artificial flaws that closely simulate the mechanical properties of fatigue cracks. Currently used artifacts include electrical-discharge-machined and saw-cut notches, both of which are relatively poor representations of fatigue cracks as their widths are too great. The Division-developed method provides notches that can be made controllably in a variety of geometries, have known dimensions, with widths that are narrow enough to provide an acceptable representation of fatigue cracks.

An NIST Research Material is not certified by NIST, but meets the International Standards Organization definition of "a material or substance one or more properties of which are sufficiently well established to be used in the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials." The documentation issued with RM 8458 is a "Report of Investigation." Contact: technical information -- Fred Fickett, (303) 497-3785; order information -- Office of Standard Reference Materials, (301) 975-6776.

Additional Information (cont'd.)

EMERGING TECHNOLOGIES IN ELECTRONICS...AND THEIR MEASUREMENT NEEDS, SECOND EDITION

This report assesses the principal measurement needs that must be met to improve U.S. competitiveness in emerging technologies within several fields of electronics: semiconductors, superconductors, magnetics, optical fiber communications, optical fiber sensors, lasers, microwaves, video, and electromagnetic compatibility. The report seeks feedback from industry and Government agencies on the assessment. The feedback will guide the development of NIST programs that provide U.S. industry with new documented measurement methods, new national reference standards to assure the accuracy of those measurement methods, and new reference data for electronic materials. Copies may be obtained by ordering Report No. PB90-188087/AS ($23.00 hard copy, $11.00 microfiche) from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, (703) 487-4650.

JAN. 1, 1990 CHANGES IN THE U.S. ELECTRICAL UNITS

Effective January 1, 1990, the U.S. as-maintained (i.e., "practical") units of voltage and resistance were increased by 9.264 ppm and 1.69 ppm, respectively. The increases in the U.S. legal units of current and of electrical power will be about 7.57 ppm and 16.84 ppm, respectively. These changes result from efforts by the major national standardizing laboratories, including the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), to re-evaluate their as-maintained units in terms of the International System of Units (SI). The consequence of this activity has been the introduction of standards representing the SI units of voltage and resistance by the International Committee of Weights and Measures, an international body created by the Treaty of the Meter.[1] The use of these standards world-wide beginning January 1, 1990, will result in international consistency of electrical measurement as well as coherence among the practical units of length, mass, electricity, time, etc., inherent in the definitions of the SI.

Implementation of Changes at NIST

These changes have been instituted in the U.S. by NIST using the new, internationally-adopted constants K_{J-90} = 483 597.9 GHz/V exactly and R_{K-90} = 25 812.807 Ω exactly with the Josephson and quantum Hall effects to establish representations of the SI volt and ohm, respectively. The representation of the SI volt is attained by using K_{J-90} in the formula

$$U_J(n) = \frac{f}{K_J} \qquad n = 1,2,3,...$$

to give the voltages $U_J(n)$ of the steps produced by the ac Josephson effect at a frequency f. The past value, K_{J-72}, was 483 593.42 GHz/V(NBS-72), thus leading to the 9.264 ppm change. Likewise, R_{K-90} is used in the following formula for the resistance of the i^{th} plateau of a quantum Hall effect device,

$$R_H(i) = \frac{R_K}{i} \qquad (R_K = R_H(1))$$

to realize a representation of the SI ohm. The most recent past national unit of resistance, $\Omega(NBS\text{-}48)_t$, was based on a group of five Thomas one-ohm standards and had an uncompensated drift rate of approximately -0.053 ppm per year. Since the quantum Hall effect is used as the national standard, the U.S. representation of the ohm has no drift. (The past

[1]Note that the SI Units have not been redefined; rather, they have been realized more accurately and a quantum physics representation of the ohm has been introduced, thus leading to the changes in magnitude of the practical or as-maintained units.

Additional Information (cont'd.)

unit of voltage, V(NBS-72), was based on the Josephson effect since 1972, and accordingly had a zero drift rate.)

Reassignments to Non-adjustable Standards

Since the U.S. practical volt and ohm units increased on January 1, 1990, the changes must be implemented in non-adjustable standards calibrated in terms of V(NBS-72) and/or Ω(NBS-48) only by **reducing** the values assigned to them proportionally. The examples given below show how to do this for a standard cell and a standard resistor.

Sample Adjustments of Values of Standards

Standard cell:

"Old" emf 1.0180564 V(NBS-72)

Multiply "Old" emf by 0.999990736 to get emf in terms of the present volt representation 1.01804697 ≈ 1.0180470 V

Standard resistor:

"Old" resistance value
9999.976 $\Omega(\text{NBS-48})_{01/01/90}$

Multiply "Old" resistance by 0.99999831 to get the resistance in terms of the present ohm representation
9999.9591 ≈ 9999.959 Ω

In the above, "Old" refers to the value of the standard which would have been in use on January 1, 1990, had the changes not been made; i.e., if a correction curve based on its past assigned values has been employed to obtain the currently-used value for a standard, the above represents a downward shift of the curve starting January 1, 1990. For resistance, the slope of the curve also changed (slightly) since Ω(NBS-48) has a drift rate and Ω(NIST-90) does not.

Do not send your standards to NIST for recalibration on January 1, 1990, unless they are normally due then. The changes are accurately known and corrections to existing standards may be applied.

Adjustment of Instrumentation

An assigned or calibrated value of a standard is merely a label giving the magnitude of the parameter embodied in the standard. The actual emf or resistance of a standard did not change on January 1, 1990; only what it is called should have changed. In the same sense, meter readings are labels giving the magnitudes of the parameters being measured. **Readings taken after January 1, 1990 using unadjusted meters will be too large in magnitude.** Adjustments to meters must have the effect of reducing the amplitudes of readings for fixed emf's or resistances.

Adjustable voltage and current sources or adjustable resistors for which nominal output is desired, on the other hand, must have their outputs **increased** proportionally by the above amounts. DVM calibrators are probably the largest class of this type of instrument.

Guidelines

The National Conference of Standards Laboratories (NCSL) and NIST have formed NCSL *ad hoc* Committee 91.4, Changes in the Volt and Ohm to assist industry and government laboratories in coming into compliance with the changes. A major responsibility of the committee is the generation and publication of a set of guidelines which describes unambiguous methods for adjusting standards and instruments, or their values, and delineates other types of problems which may arise, e.g., voltage values called out explicitly in maintenance procedures, values imbedded in software, and the like. These guidelines have been published as NIST Technical Note 1263, "Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990." This document is available at no charge through the

Additional Information (cont'd.)

NIST Electricity Division. To receive a copy, contact Sharon Fromm at 301-975-4222.

For further information, contact Norman B. Belecki (301-975-4223), Ronald F. Dziuba (301-975-4239), Bruce F. Field (301-975-4230), or Barry N. Taylor (301-975-4220).

U.S. REPRESENTATIONS OF ELECTRICAL POWER AND ENERGY

Watt, Var, Volt-Ampere
Joule, Watthour, Varhour
Volt-Ampere-hour, and Q-hour

Background

By international agreement, starting on January 1, 1990, the U.S. put into place new representations of the volt and ohm based, respectively, on the Josephson and Quantum Hall effects and which are highly consistent with the International Systems of Units (SI). Implementation of the new volt and ohm representations in the U.S. required that on January 1, 1990, the value of the present national volt representation maintained by the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards) be increased by 9.264 parts per million (ppm) and that the value of the national ohm representation be increased by 1.69 ppm (1 ppm = 0.0001%). The resulting increase in the national representation of the ampere is 7.57 ppm. The resulting increase in the national representations of the electrical quantities of power, namely the watt, var, and volt-ampere, and the quantities of energy, namely the joule, watthour, varhour, volt-ampere-hour, and Q-hour is 16.84 ppm.

The adjustment for electrical power and energy is generally very small compared to revenue metering measurement uncertainties (typically greater than ±0.1%) and therefore are not likely to have a significant effect. Adjustments do not need to be applied in the above instances. However, for the highest accuracy calibrations of power and energy standards having uncertainties less than ±0.020%, adjustments should be made. Accordingly, all Reports of Calibration and Reports of Test issued by NIST after January 1, 1990, reflect the appropriate changes.

For instruments calibrated prior to January 1, 1990, adjustments to the calibration values due to the change in the volt and ohm can be made without instrument recalibration. The adjustments are exact and, if properly applied, will not introduce any errors. Examples given below will illustrate proper procedures for applying the new adjustments.

Adjustments for Wattmeters, Varmeters, and Volt-Ampere Meters

Calibrations of wattmeters, varmeters, and volt-ampere meters at NIST provide customers with corrections and uncertainties given in units of watts, vars, or volt-amperes, as appropriate. Applying the appropriate adjustment due to the new representations of the volt and ohm for power measuring instruments (i.e., wattmeters for "real power" and varmeters for quadrature or imaginary power) requires minor calculations. First, it is necessary to assess the magnitude of the calibration uncertainty in percent and then decide if applying adjustments for the change in the volt and ohm are required. To determine the percentage uncertainty, simply divide the uncertainty in watts, vars, or volt-amperes by the product of the applied voltage and current times the power factor (the real power) and multiply that quantity by 100, as

$$U\% = [(U_w, U_v, \text{ or } U_v a)/(V_a \times I_a \times PF)] \times 100,$$

where

$U\%$ is the uncertainty in percent,
U_w is the calibration uncertainty in watts,
U_v is the calibration uncertainty in vars,

Additional Information (cont'd.)

V_{va} is the calibration uncertainty in volt-amperes,
V_a is the applied voltage in volts,
I_a is the applied current in amperes, and
PF is the power factor (including its sign).

For example, if the uncertainty is stated on a Report of Calibration as ±0.060 watts for the calibration of a wattmeter at an applied voltage of 120 V and an applied current of 5 A at unity power factor, then

Percent Uncertainty = U% = [(±0.060 W)/ (120 V x 5 A x 1)] x 100 = ±0.010%.

If the percentage uncertainty, as calculated above, is less than ±0.020%, (as it is in the above example), then it is recommended that an adjustment of 0.0017% (0.001684% rounded to four significant decimal places) due to the new representations of the volt and ohm be applied.

The second step is the calculation of how large the adjustment will be (in units of watts, vars, or volt-amperes, as appropriate), due to the reassignment of the volt and ohm.. For the same example given above, if the calibration correction was given in a Report of Calibration as +0.052 watts, then the adjustment due to the change in the volt and ohm may be calculated by multiplying the product of the applied voltage and current times the power factor by 0.000017 (0.0017% expressed in proportional parts), as

Adjustment = (V_a x I_a x PF) x 0.000017
Adjustment = (120 V x 5 A x 1) x 0.000017 = 0.010 watts.

The resulting product should be rounded to the same number of significant decimal places as the old calibration correction was given. This result is then subtracted from the old calibration correction, as in the following example:

Old Calibration Correction (prior to 1/1/90) = {+0.052 watts}
less 0.000017 x Applied Volt-amperes x PF = -{+0.010 watts}
New Calibration Correction (after 1/1/90) = {+0.042 watts}

If the old calibration correction (prior to 1/1/90) at test conditions of 120 V, 5 A, and at a power factor of 0.5 lag, happened to be a negative quantity, for example, -0.031 watts, then the old calibrations correction would be decreased (made more negative) by 0.0017% of the applied volt-ampere product times the power factor, as in the following example:

Old Calibration Correction (prior to 1/1/90) = {-0.031 watts}
less 0.000017 x Applied Volt-amperes x PF = -{+0.005 watts}
New Calibration Correction (after 1/1/90) = {-0.036 watts}

The process of making the corresponding change for the varmeter corrections is identical to that show above. For volt-ampere meters, the adjustment is made independent of the power factor (i.e., a value of PF = 1 may be used). However, most varmeter and volt-ampere meter calibrations have stated uncertainties greater than ±0.020%, and hence, would not require an adjustment.

Adjustments for Joule, Watt-, Var-, Volt-Ampere- and Q-Hour Meters

Applying adjustments to electric energy measuring instruments (i.e., joule, watt-hour, varhour, volt-ampere-hour, and Q-hour meters) for changes in the representation of the volt and ohm, is more straightforward because the common calibration constant for energy metering is expressed as a "percentage registration." The amount the registration is to be adjusted can be subtracted directly as a percentage, regardless of power factor.

For example, if a watthour meter has a registration of 100.015% before January 1, 1990, then after that date, the new

Additional Information (cont'd.)

assigned registration would be decreased by 0.0017% (rounded from 0.001684%) as

Old percentage registration (prior to 1/1/90)	=	100.015%
less amount due to change in volt and ohm	=	-0.0017%
New percentage registration (after 1/1/90)	=	100.0133%
Rounded to three significant decimal places	=	100.013%

The process of making the corresponding changes for the joule, varhour, volt-ampere-hour and Q-hour meters are identical to that shown above. If the associated uncertainty of the calibration is greater than ±0.020%, no adjustments are necessary, as stated in the instances for wattmeters, varmeters, and volt-ampere meters. The uncertainties for varhour, volt-ampere-hour, and Q-hour meters are seldom less than ±0.020%, and hence adjustments generally do not need to be made.

Reference

N. B. Belecki, R. F. Dziuba, B. F. Field, and B. N. Taylor, Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990, NIST Tech. Note 1263, June, 1989.

Copies of the above document are available at no cost from:

National Institute of Standards and Technology
Electricity Division, MET B146
Gaithersburg, MD 20899
Telephone: (301) 975-4222

For Further Information

For further information concerning the above information, contact either John D. Ramboz (301) 975-2434 or Thomas L. Nelson (310) 975-2427, or write:

National Institute of Standards and Technology
Electricity Division, MET B344
Gaithersburg, MD 20899

NEW BROCHURE FOR SEMICONDUCTOR SRMs

Standard Reference Materials for Semiconductor Manufacturing Technology lists a series of SRMs for use in characterizing semiconductor materials and processes. The SRMs include a series of silicon resistivity materials for calibrating four-probe and eddy-current test equipment [Technical Contact: James R. Ehrstein, (301) 975-2060]; sizing materials for calibrating optical microscopes [Technical Contact: Robert D. Larrabee, (301) 975-2298]; SRMs for optical measurements [Technical Contact: Jon Geist, (301) 975-2066]; and sizing materials for calibrating scanning electron microscopes, SRMs for mechanical testing, X-ray and photographic films, X-ray diffraction, and the chemical analysis of materials [General Contact: Office of Standard Reference Materials, Cindy Leonard, (301) 975-2023].

1991 CEEE CALENDAR

April 2-4, 1991 (NIST, Gaithersburg, MD)

NIST Workshop on Testing Strategies for Analog and Mixed-Signal Products. This workshop is intended to teach a new approach for optimizing the tradeoffs associated with production testing of analog and mixed-signal devices. Examples of products that can benefit from this testing approach range from integrated circuit digital-to-analog and analog-to-digital data converters to programmable filters to multirange precision instruments. The workshop is intended for test engineers, automatic test equipment applications engineers, calibrations laboratory managers, and others interested in improving the efficiency of testing analog and mixed-signal products. A small set of practical mathematical tools will be introduced, with an emphasis on implementation using commercial software rather than on mathematical development. Some familiarity with the concepts of linear algebra and elementary

Additional Information (cont'd.)

statistics would be useful, but is not a requirement. The workshop will feature practical examples and hands-on training. [Contact: T. Michael Souders, (301) 975-2406]

September 8-11, 1991 (Research Triangle Park, NC)

Third Workshop on Radiation-Induced and/or Process-Related Electrically Active Defects in Semiconductor-Insulator Systems. This workshop is sponsored by the Microelectronics Center of North Carolina (MCNC), North Carolina State University, and the University of North Carolina at Charlotte, in cooperation with the Semiconductor Research Corporation, the IEEE Electron Devices Society, and the National Institute of Standards and Technology. Some areas of interest are: relationships between processing and electrically active defect densities, measurement methods, theoretical modeling of electrically active defects, process control of the sensitivity of insulators to ionizing radiation, removal of radiation damage, controlled radiation standard sources, and memory effects. [Contact: Jeremiah R. Lowney, (301) 975-2048]

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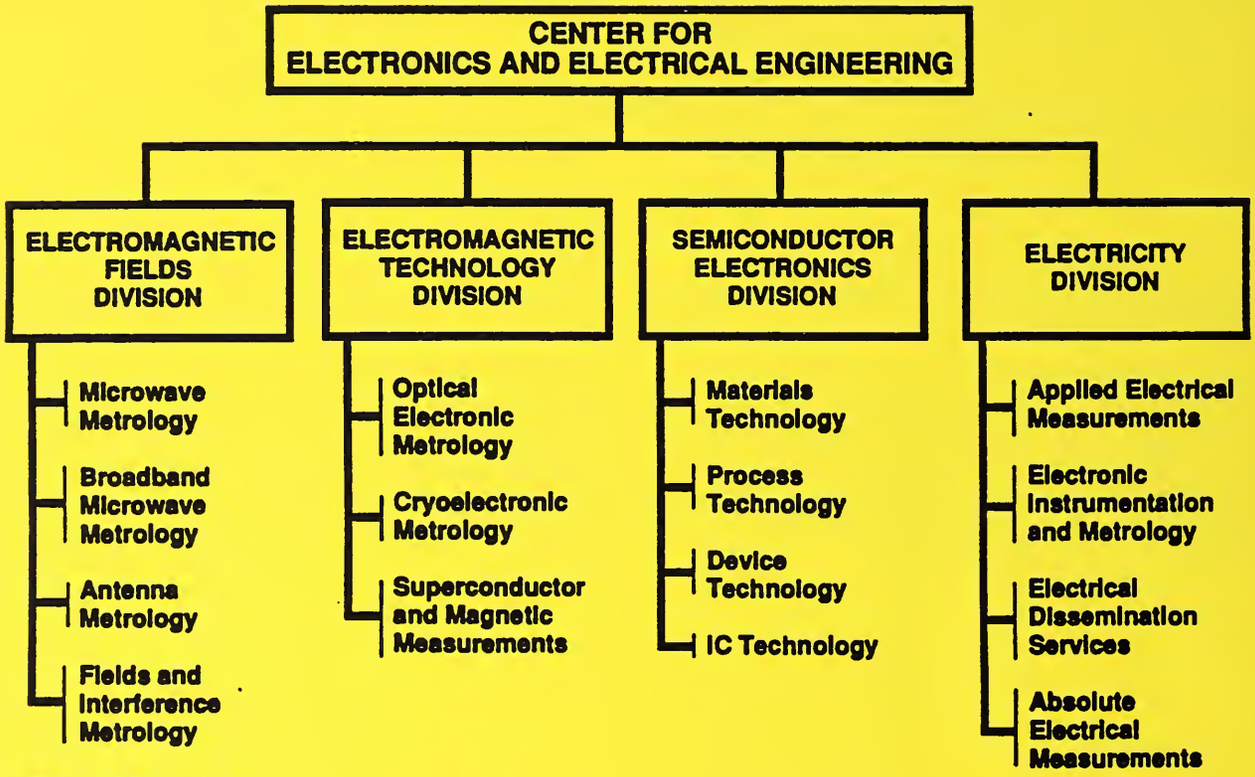

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